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ABSTRACT

The end point of exercise occurs when the subject can no longer continue the activity due to pain, weakness, or boredom. Shortly following the exercise, however, most subjects report that they could have worked longer--indicating a memory loss or escape from pain previously encountered. This study was an attempt to examine the physiological parameters at the time of these subjective feelings of fatigue to learn if motivation to exercise would change with changing physiological measurements. An experienced athlete in good health but untrained for competition was asked to exercise in a series of tests. Results indicate that psychological motivation is influenced by physiological parameters that fall within rather narrow ranges; the question is, Which comes first? Heart rate, ventilaticns, oxygen uptake, and body termperature levels are controlled by factors other than a desire to end the exercise. Physical training probably takes long periods of time because of the time needed for slow biological adaptation to take place. Motivation relates to the capability of the body, acting as a feedback system, to inform the higher centers of break point levels. The desire to be a good athlete must be coupled with the biological capability to adapt to exercise. (Authors/JA)

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PSYCHOLOGICAL LIMITS IN ATHLETIC TRAINING

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The authors have been involved recently in studies of work capacity of athletes and have been interested in the comments made following all-out exercise. The end point of exercise occurs when the subject can no longer continue the activity due to pain weakness, or boredom. Shortly following the end of the exercise, however, most of the subjects report that they could have worked longer. The recovery following the exercise apparently results in a type of memory loss or escape from pain previously encountered. The present study was an attempt to examine the physiological parameters at the time of these subjective feelings of fatigue to learn if the motivation to exercise would change with changing psysiological measurements.

An athlete in good health but untrained for competition was asked to exercise in the laboratory on two occasions to test his maximal O_2 uptake capacity. The subject was at an earlier date one of the top decathlon men in track and field in the United States and accustomed to hard physical work. He was 32 years old, 186 cm. in height and weighed 85.5 kg. The tests for maximal VO_2 resulted in a maximal heart rate level of 188/min. with a maximal V of 90.4 L. and a maximal VO_2 of 3.79 L. (STPD).

Methods

The authors have determined previously that subjects can exercise up to eight hours with 50 minutes exercise and 10 minute at rest at energy levels around 35% of their maximal capacity (VO_2). We selected a similar kind of exercise-rest schedule to allow us to follow changes in the physiological parameters and to give the subject the choice of deciding his capability to continue exercise after a short recovery period each hour.

The subject exercised on a treadmill with the speed and slope set to result in an energy cost of approximately 30-50 per cent of this maximal effort during the first hour so that he would propably stop exercise between six and eight hours. The room temperature was 7 °C. The exercise lasted 50 minutes, followed by 10 minutes of rest, then 50 minutes of exercise, etc.. The exercise terminated when the subject felt he could not complete the next 1/4 hour of exercise. Food and water were available when wanted, and the subject was paid according to the work done.

The exercise was repeated each day until the subject refused to continue the activity. One month later the exercise was repeated with the work load increased to equal the effort found the last hour of the previous series of walks. Following this work, the subject returned to the laboratory 3 months later for a third series of walks with the work loard similar to the previous walk but with the temperature increased to 23 °C to approximate the energy output found the last hours of the

previous walk. Each 10 minutes the rectal and skin temperature were obtained with constantin copper thermocouples and the heart rates estimated with EGG tracings. Three minute ventilation samples were collected in spirometers at the 25th and 45th minute of each exercise hour. Aliquots were analysed by Haldane technique.

Results and Discussion

The results of the studies are found in Table I. Though measurements were taken each hour, the results presented represent only those taken at the end of the first and of the final hour of exercise.

The first exercise series resulted in the subject becoming increasingly more hostile and irritable at the start of each days work and particularly hostile during the least hour of exercise. Boredom and specific aches and pains were reported throughout the testing. The physiological parameters changed gradually throughout the tests, which lasted for six hours each of the first three days. On the fourth way, the subject exercised for only 3½ hours and had to stop due to edema of the foot.

The second series of tests lasted three days with the subject deciding he couldn't take any more time away from his family and that the money he was earning didn't compensate for the effort expended.

The third series of tests ended in two days with only a great amount of effort and encouragement to get the subject to finish the least few minutes of each hour of exercise. Following this series the subject refused to return for tests at any future date.

The six hour exercise (days 1-3) ended with the physiological measurements at approximately the same level as the 4th work day which lasted only 3½ hours. The psychological limit to exercise occurred then whenever the physiological parameters were at some particular level. With the first exercise this was when the O_2 uptake was 51% of the maximal ability. The exercise was performed at above 46% of the maximal level for six hours.

With the next exercise series, the subject had no desire to continue work after exercising above 58% of the maximal VO_2 level for 2½-4 hours. The break point occurred when the energy output was around 66% of the maximal level.

With the last series of tests, the exercise lasted only 2 hours and 2 days with the O_2 uptake the first hour around 75% of the maximal capatability and ended each day when the energy level reached about 80% of the maximal level.

The rectal temperature was between 38° and 39 °C on all tests at the break point with the exception of the test terminating due to edema of the foot.

The heart rate response during the first hour gave an indication when the exercise would end similarly to that shown in previous work at Santa Barbara. When the rate per minute was around 120, 60% maximal, the exercise lasted six hours; when the rate per minute was around 140, 75% maximal, the activity could be carried out for four hours; and when above 160, 85% maximal, the exercise ended in two hours.

When an athlete conditions himself for a sport, the work out period usually lasts around one to two hours. If the energy output is at a level

TABLE I

MEASUREMENTS TAKEN AT END OF FIRST AND LAST HOUR

Exercise	Heart Rate per min.	V (L) (STPD)	VO_2 (L) (STPD)	Rectal Temp. (C)	Walking Time (Hrs.)
3.0 MPH 6% 7°C					
Test 1	110 - 147	32.8 - 34.3	1.75 - 1.92	37.1 - 38.2	6
Test 2	112 - 147	31.5 - 34.5	1.78 - 1.94	37.1 - 38.2	6
Test 3	112 - 133	31.3 - 35.5	1.65 - 1.91	———	6
Test 4	112 - 120	30.9 - 38.3	1.75 - 1.95	37.0 - 37.2	3½
3.5 MPH 10% 7°C					
Test 1	137 - 172	49.2 - 56.3	2.14 - 2.67	37.4 - 38.7	4
Test 2	143 - 166	48.8 - 59.0	2.20 - 2.30	37.2 - 38.5	2½
Test 3	144 - 167	50.9 - 55.2	2.29 - 2.56	37.4 - 38.7	3½
3.5 MPH 10% 23°C					
Test 1	173 - 193	55.4 - 83.0	2.92 - 3.15	37.4 - 38.7	2½
Test 2	161 - 188	55.7 - 88.3	2.80 - 2.97	37.4 - 38.9	2

similar to that found in this study, the fatigue and disinclination to train should show up in a few days. Periodic rest days or periods of light work outs may be important to prevent the accumulation of metabolic products or to allow time for the adjustments necessary to counteract fatigue.

The complaint by the subject that the calf muscle, the ankle, the foot, the back, or other body parts botered him has been noted before in coaching athletes. This localization of irritating stimuli may be an indication of general body fatigue or need for rest.

The motivation to exercise perhaps can best be obtained if a slow gradual progress is allowed so that there is time for the physiological adaptations to take place. When sudden physiological changes occur in the body, the mental outlook or motivation is certainly affected, and apparently in an accumulative way.

The present study suggests that psychological motivation is influenced by physiological parameters that fall within rather narrow ranges. This, of course, leads to the question: which come first, the chicken or the egg? Though it is possible that an exercise may end if an athlete has psychologically decided he should stop and this desire brings about physiological changes, it is doubtful that such precise end point measurements, as found

in the present study, would be seen. The heart rate, ventilations, O_2 uptake and body temperature levels are certainly controlled by factors other than the desire to end the exercise. Physical training probably takes long periods of time because of time needed for the slow biological adaptation to take place. The motivation then relates to the capability of the body acting as a feed back system to inform the higher centers of break point levels.

The desire to be a good athlete must be coupled with the biological capability to adapt to exercise. It is suggested in this and in other studies at Santa Barbara that the limitations to physical training relate to a large extent to the built in mechanisms that perhaps protect the boody from injury. The athlete is not much different from a non-athlete with regards to pain tollerance of the ability to withstand stress other than that which he is trained for.

It is not known if the physiological parameters, such answere measured in our studies, reflect a protective mechanism which informs the brain that enough stress has occurred, but it is suggested that it is most likely probable.